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IAAO CONFERENCE + EXHIBITION
Aug 30 – Sept 1, 2020

Measuring the Value of Land

IAAO

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TRANSFORMING VALUATION THROUGH TECHNOLOGY

Papers

Albouy, David and Minchul Shin, “A Statistical Learning Approach to Land Valuation: Optimizing the Use of External Information.”

Bourassa, Steven and Martin Hoesli, “Land Valuation using a Mix of Hedonic and Depreciated Cost Methods.”

Clapp, John and Thies Lindental, “The Valuation of Urban Land: Comparison and Critique of Three CAMA Methods.”

Cohen, Jeffrey, “Land Value Estimation in Maricopa County, AZ: A Space-Time Local Regression Approach.”

Johnson, Erik, “Land Values and Machine Learning.”

Larson, William and Jessica Shui, “Land Valuation using Public Records and Kriging: Implications for Land versus Property Taxation in Cities.”

McMillen, Daniel and Ruchi Singh, “Land Valuation using Teardowns.”

Peltola, Risto, “Automated Land Valuation in Maricopa County.”

Vandell, Kerry and Arsenio Staer, “Parcel-Specific Land Valuation at the Metropolitan Scale: An Option Theoretic Approach.”

Yang, Zhou, “A Modern Approach to Land Valuation: An Application of Artificial Neural Networks.”

Zabel, Jeffrey, “A Matching Method for Land Valuation.”

Approaches

1. Vacant Land Sales

   Larson & Shui, Peltola

2. Hedonic Price Functions: Regression of house prices on characteristics of the structure and location. A sub-category is machine-learning approaches.

   Cohen, Johnson, Yang, Zabel

3. Depreciated Cost / Residual Approaches: Estimate overall property value using a comparable sales / hedonic approach, subtract cost of building the structure as if it were new, add estimate of depreciation. Leftover is land value.

   Bourassa & Hoesli, Larson & Shui, Clapp & Lindenthal

4. Teardowns

   McMillen & Singh

5. Hybrid Approaches: First estimate land/price ratio then apply to hedonic price function estimates, or estimate a function for improvements and subtract from the price function. Also a Bayesian approach.

   Albouy & Shin, Bourassa & Hoesli, Clapp & Lindenthal

Issues with Vacant Land Sales

Geographic coverage: built up areas tend to have few sales.

How representative are vacant land sales?

Can be very hard to classify correctly. A sale of a lot next to a home may carry one price for the combination. Extremely large CODs of nearly 50 led Bourassa and Hoesli to reject the approach.

But may work very well in areas with many new developments.

Vacant Land Sales – Bourassa and Hoesli Results, 6,119 sales for 2015-2018

	Coef.	Std. Err.	Zoning:	Coef.	Std. Err.
Log of land area	0.3913	0.0197	Planned development	0.9102	0.0790
Distance to CBD	-0.0505	0.0016	Town house	1.8850	0.3984
Flood zone*			Min. lot 4,000-9,000 sq. ft.	0.1795	0.0795
Floodway	-0.0058	0.0014	Min. lot 10,000-24,000 sq. ft.	0.7096	0.0799
Flood fringe	0.0030	0.0011	Min. lot 30,000-35,000 sq. ft.	0.5022	0.0837
Flood plane	-0.0049	0.0005	Min. lot 1 acre	0.1101	0.0824
Subdivisible*	0.1217	0.0314	Min. lot 70k to 190k sq. ft.	0.6538	0.1290

$R^2 = 0.695$. Include quarter of sale and 22 market area dummies.

Some Ways to Address Issues with Vacant Land Price Regressions

Matching approach. Zabel's paper is an example.

- Construct a sample of similarly sized lots, perhaps with more weight on lots closer to the size of the property under consideration.

Highly nonlinear approach, e.g., locally weighted or geographically weighted regression.

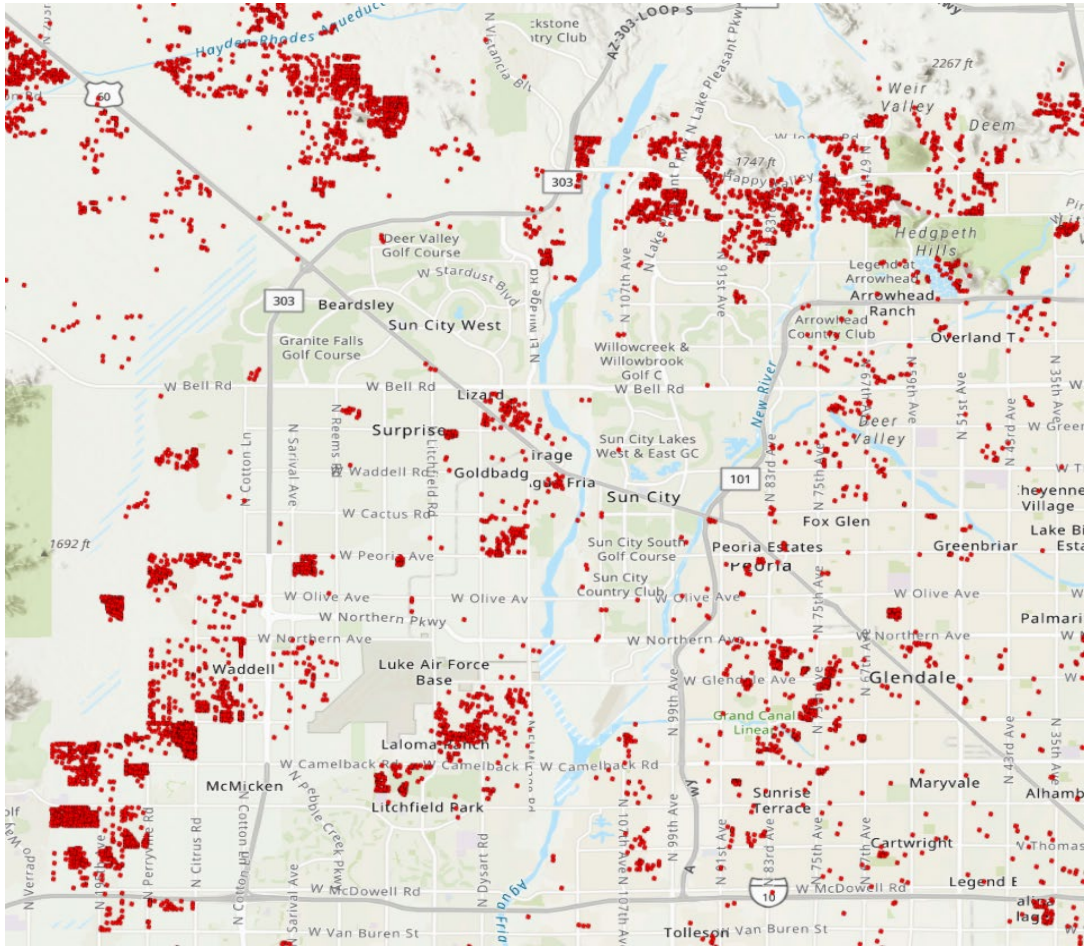
- Similar to matching approach. Places more weight on nearby lots that have similar lots sizes.

Can be a useful approach in areas with a good number of vacant land sales.

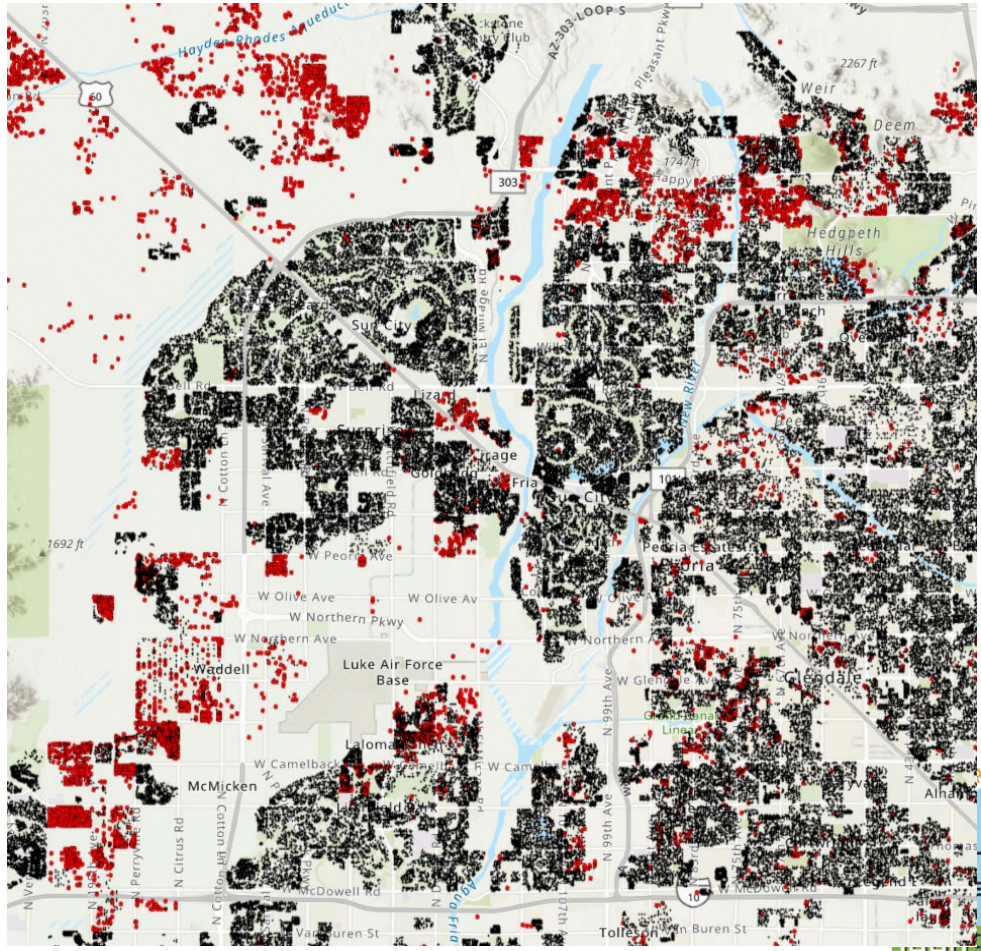
An important issue is whether vacant lots are fundamentally different from improved parcels – sample selection.

Geographic Coverage, Vacant Land Sales, 2000 - 2018

Land Sales



Land Sales (red), House Sales (black)



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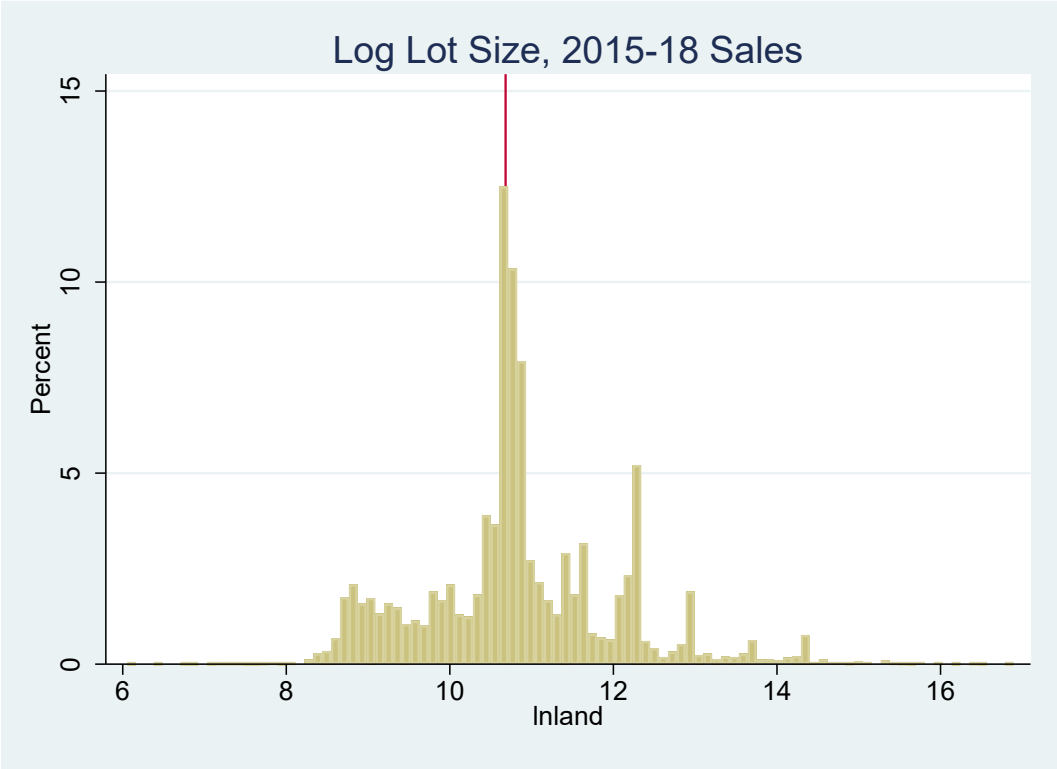
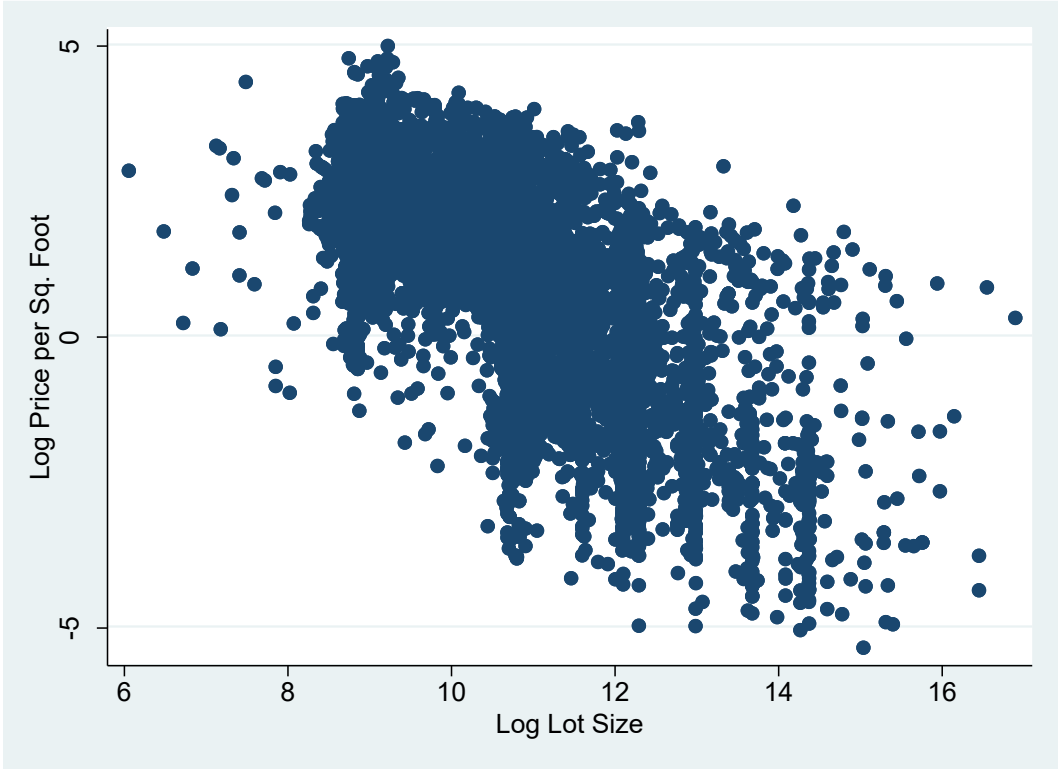
Lot Sizes

Many very large lots (red line indicates 1 acre, log = 10.68)). Tends to be a discount for large lots on a per acre basis. Can lead to an underestimate of the value of smaller lots.





Hedonic Approach – CAMA

Let Z = Characteristics of the lot and location, e.g., acreage, frontage, census tract or neighborhood, etc.

X = Characteristics of the structure, e.g., interior area, # bedrooms, etc.

Y = Sale price, either level or natural logarithm

D = Controls for time of sale, e.g., quarter or year.

"Hedonic Price Function:"

$Y = Z\lambda + X\beta + D\delta + u$

$Z\lambda$ is the value of land/location.

Advantages and Disadvantages of the Hedonic Approach

The workhorse approach for academics.

Advantages relative to vacant land sales:

- Much larger number of observations, more representative of the overall market.
- *Might* be easier to value overall property value than value of vacant land.

Disadvantages:

- Any missing variable that is correlated with included variables biases coefficient estimates. An especially significant problem for land values because missing variables are highly likely to be correlated with the location variables, Z. Example: pools or exceptionally high-quality construction materials.
- An indirect way of measuring land value.

Advantage of sample size can be exaggerated. If X is hard to measure accurately and the variance of land values is low, a much smaller number of vacant land sales may be needed to estimate land value accurately.

Example of Hedonic Price Estimates: Bourassa & Hoesli

Variables from vacant price regression are also included. Number of observations is 301,488 instead of 6,119. R^2 = 0.849 v. 0.695.

Variable	Coef.	s.e.	Variable	Coef.	s.e.
Log of floor area	0.4296	0.0021	Carport	0.0552	0.0020
Basement	-0.0141	0.0038	Garage	0.1333	0.0020
Bathrooms	0.0381	0.0008	Golf cart garage	0.2853	0.0068
Improvement class:			RV garage	0.0671	0.0058
3	0.3181	0.0055	Airplane hangar	0.3712	0.0418
4	0.4055	0.0056	Barn	0.0247	0.0094
5	0.5929	0.0060	Storage shed	0.0152	0.0015
6	0.8364	0.0074	Pool	0.0706	0.0009
7	0.8787	0.0317	Spa	0.0508	0.0038
Age	-0.0142	0.0001	Sports court	0.0231	0.0100

Machine Learning Approaches

Erik Johnson and Zhou Yang both use neural network approaches to account for potentially complicated nonlinearities among the explanatory variables.

Johnson combines the neural network approach with google satellite images that provide more information on characteristics of the structure and location, with an emphasis on measuring structure quality.

Alternative approaches include the lasso and the random forest approach. Focus is on choosing which variables to include in the model, but also include nonlinearities. Some data sets include dozens of structural characteristics.

Advantages: Help guide the choice of explanatory variables and functional form.

Disadvantages: To successfully estimate land values, still need to successfully control for the effect of structural coefficients and not have any remaining correlation with missing variables and the parcel characteristics. May do a great job within sample but not out of sample.

Out of Sample Predictions

Even a very large sales data set does not include all properties that must be appraised.

To improve the accuracy of predictions, studies such as Zabel's evaluate their models using a set of observations that are not included in the regression model.

Two common approaches for out of sample predictions:

1. Restrict the model specification to variables like lot size and market areas that make it possible to directly apply the estimated model to all properties.
2. Interpolation:
    1. Kriging (Larson and Shui, Yang).
    2. Geographically weighted regression, locally weighted regression, or semi-parametric approaches (Cohen).

Depreciated Cost or Residual Approach

Traditional Cost Approach: Use RS Means data on costs to calculate value of the property as if it were new. Subtract depreciation. Result is an estimate of the value of the current structure. Subtract from sale price to get land value.

Advantages: Relatively easy to calculate using RS means data for costs and depreciation. Sales prices can be estimated using hedonic approach or a traditional comparable sales approach.

Disadvantages: Estimated values can be negative. Most accurate for relatively new properties.

Bourassa and Hoesli find that the variation of land value estimates from the Depreciated Cost method is even higher than the range from a vacant land regression, with many negative values. Blame data problems.

Teardowns

Can help estimate land values in areas where teardowns are common, which also are areas that tend to have few vacant parcels.

Value of land is approximately the price of a teardown plus any demolition cost.

Advantages: A direct estimate of the value of land in places where land can be hard to appraise otherwise.

Disadvantages:

- Small number of sales. McMillen and Singh end up with only 378 usable sales in Maricopa County for 2011 – 2018.
- Probably does not generalize to other areas.
- Sample selection issues.
- Can be remarkably hard to identify teardown sales.
- How short does the time have to be between sale and demolition for the sale to count as a teardown?

Kenilworth, IL

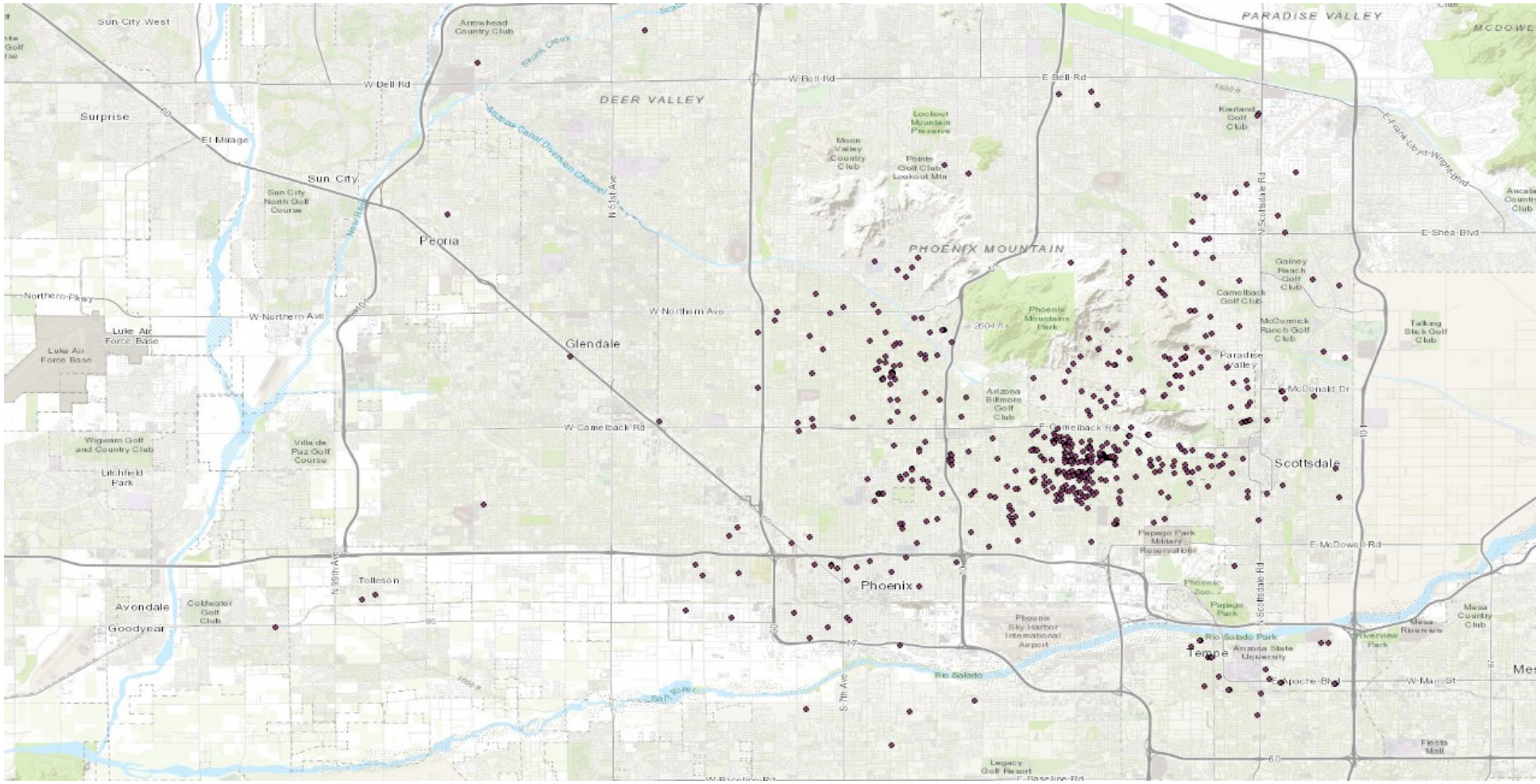
Kenilworth, IL

Teardowns as Land Sales

Naperville, IL

Teardown Sales in Maricopa County

McMillen and Singh



Combining Teardown and Non-Teardown Sales (McMillen & Singh)

1. Teardowns only: Estimate hedonic price functions with and without structural characteristics as explanatory variables. Coefficients for structural characteristics should be zero if the property is only valued for its land. Can combine the two sets of estimates by placing more weight on land-only estimates, with the weight based on the relative explanatory power of the two regressions.

2. Unconditional Expectations Approach. Based on the following:

Expected sale price = (Probability that the property is purchased as a teardown) x (Expected price as a teardown) + (1 – Teardown Probability) x (Expected price as a non-teardown).

Makes it possible to combine both teardown and non-teardown sales to estimate the value of land in active teardown markets.

Bayesian Approaches (Albouy and Shin)

1. Vacant land model: $Y = Z\lambda + u$
2. Hedonic price function for improved properties: $Y = Z\lambda + X\beta + D\delta + u$. Predicted land price is just $Z\lambda$.

Place more weight on vacant land prices in areas with many sales of vacant land.

Similar to the approach used by McMillen and Singh for teardown/non-teardown sales. Could combine the two approaches to include all three types of sales.

Advantages: A potentially effective way of combining the two types of sales to get good estimates of land values in areas with relatively few vacant parcels.

Disadvantages:

- Still have problems if vacant land sales are not representative of overall land prices.
- May be inaccurate in places that are not near many vacant parcels.
- Computationally intensive and hard to implement with standard statistical packages.

1. Hybrid Approach: "Land Leverage" (Bourassa and Hoesli)

1. Estimate a vacant land sale price index using all land sales.
2. Identify sales of the same properties once they have been improved. Subtract the estimated land price from the overall sale price. Result is an estimate of the value of improvements only.
3. Use the improvement equation to estimate improved values for all properties. Subtract from hedonic price function estimates for overall property value to estimate land value.

Problem: produces a large number of negative land value estimates.

2. Hybrid Approach – Clapp and Lindenthal

Very similar to the Bourassa and Hoesli approach but does not produce negative estimates:

1. For newly built properties, calculate ratio of total sale price to land values.
2. For later sales, use a hedonic price function to estimate overall sale price.

Notation: p(L) = price per unit of land, L. P(H) = price per unit of housing, H.

p(S) = price per unit of structure, S.

p(L)L = p(H)H - p(S)(S x depreciation)

Land/price ratio: $\frac{p(L)L}{p(H)H} = 1 - \frac{p(S)S}{p(H)H}\ x\ depreciation$

Land/price ratio declines over time. Estimate at time of construction just needs to be adjusted by depreciation rate for existing properties. Then apply the estimated land/price ratio to hedonic estimates. Estimates are never negative.

But does not work for teardown areas, where land/price ratio is near 1.

Summary and Conclusions

- Relatively easy to appraise land in places where there are lots of vacant land sales, just as it is easy to appraise house prices in areas with lots of home sales.
- Vacant land is not necessarily representative of land value in locations with few sales – why are the lots vacant?
- Teardowns can help estimate land values in places where they are common. Important because these locations tend to have few vacant lots.
- Approaches based on residuals are problematic because they frequently imply negative land values.
- Approaches based on calculating land/price ratios are very promising. Rules of thumb such as land value = 25% of property value are only applicable for new properties and are likely to vary across regions.
- Land is likely to account for a larger portion of overall property value in areas with older homes and high values.

Thank You!

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